WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
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Journal of Food, Agriculture & Environment Vol.5 (3&4) : 102-104. 2007 *www.world-food.net*

Mineral composition and total phenolic content of pomegranate molasses

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Received 7 July 2007, accepted 12 August 2007.

Abstract

Pomegranate molasses, a concentrated product of pomegranate juice, is widely used as a condiment in various foods. In this study, mineral composition and total phenolic content of pomegranate molasses were determined besides other chemical properties. Even though processing steps include clarification and filtration, pomegranate molasses were a good source for minerals such as calcium (280 mg/kg), phosphorus (16 mg/kg), potassium (20 mg/kg), iron (16 mg/kg), zinc (7 mg/kg) and magnesium (28 mg/kg). Total phenolic content of pomegranate molasses was about 52 mg gallic acid equivalent/g. High mineral and phenolic content of pomegranate molasses could contribute to the total intake of these constituents in human diet.

Key words: Pomegranate, pomegranate molasses, minerals, total phenolic content.

Introduction

Pomegranate molasse is a thick syrup made from cooked-down pomegranate (*Punica granatum* L.) juice, which is a slightly astringent, sweet-sour condiment that is deep and dark (and slightly ruby) in color. Production of pomegranate molasses typically includes cleaning and crushing of pomegranates, extraction, filtration, clarification and concentration of pomegranate juice. Commercial pomegranate molasses are also called pomegranate sour. Pomegranate molasses have had various applications as a flavoring agent, a salad dressing or soft drink ingredient. The sweetness results from the concentration of the fruit's natural sugars. Although their organic acid and sugar composition depends on the variety, climate and the degree of maturation, pomegranate fruits contain predominantly citric and malic acids and glucose, fructose, sucrose and maltose [1].

Edible portion of pomegranates is a good source of minerals like potassium and antioxidative constituents like ascorbic acid and α- and β-carotenes [2]. Potassium content of fresh pomegranate juice may range from 130 to 330 mg/100 g although chemical composition of fresh pomegranate juice and seeds depends on the maturity level of fruits [3, 4]. Fresh pomegranate juice and fruit extract are also rich in anthocyanins, hydrolyzable tannins, ascorbic acid and other antioxidants [5-7]. Regular consumption of dietary pomegranate juice has been reported to have beneficial effects on human health [8-11]. Pomegranate fruit extract may exhibit radical scavenging activity against hydroxyl and superoxide radicals [12] and chemopreventive effect against cancer in mice [13]. Methanolic extracts of pomegranate may reduce gastric ulcer formation [14]. Pomegranate molasses, concentrated pomegranate juice products, may have two to three folds higher mineral and antioxidant content than fresh pomegranate juice.

The aim of the present study was to determine mineral composition and total phenolic content of pomegranate molasses besides other properties such as moisture content, flow behavior index, protein content, pH and Hunter *Lab* color values.

Materials and Methods

Samples: Molasses of pomegranates (*Punica granatum* L.) were of Arifoglu Spice and Food Corporation (Istanbul, Turkey), a major producer in Turkey. Molasses with different batch numbers (n = 3) were purchased from local supermarkets and used to determine the analytical and rheological properties of pomegranate molasses. Duplicates of each batch of pomegranate molasses were analyzed in each experiment.

Analytical measurements: Dry matter, ash and protein contents of pomegranate molasses were determined according to AOAC [15] procedures. The micro-Kjeldahl method was used to determine nitrogen content of pomegranate molasses, and the results were multiplied by a factor (6.25) to determine crude protein content [15]. Specific gravity of pomegranate molasses was determined according to Lee and Hoseney [16] at room temperature. The pH of pomegranate molasses was measured using a pH meter at about 17.5°C. Color values were determined by Hunter-Lab Mini Scan XE colorimeter (Reston, VA, USA). The Hunter color values were expressed as *L* (whiteness or brightness/darkness), *a* (redness/greenness) and *b* (yellowness/blueness) [17].

A Perkin Elmer Optima 2100 DV model (Shalton, USA) inductively coupled plasma spectrometer was used to determine mineral elements (K, Na, Ca, Mg, Mn, Cu, Zn, Fe and P) in pomegranate

molasses according to Barnes [18]. Operating conditions of the instrument were as follows: RF power, 1,450 W; coolant gas flow, 15 L/min; auxiliary gas flow, 0.2 L/min; nebulizer 0.8 L/min; heater, 30°C; delay time, 60 s; plasma view, axial; sample flow rate, 1.5 mL/min. Sensitive wavelengths for mineral identification were obtained from the tables provided by the manufacturer [19]. Signal changes over time were corrected using an external drift monitor. Averages of readings from all replicates were reported.

Total phenolic contents of pomegranate molasses were determined according to Folin-Ciocalteu method [20]. Folin and Ciocalteu's phenol reagent and sodium carbonate were purchased from Sigma® (St. Louis, MO) and Fisher Scientific (Fair Lawn, New Jersey), respectively. Gallic acid (Aldrich Chem. Co., Milwaukee, WI) was used as a standard. A Shimadzu UV-1601 spectrophotometer (Shimadzu Scientific Instruments, Inc., Tokyo, Japan) was used to determine the total phenolic contents of commercial pomegranate molasses.

Rheological measurements: Consistency coefficient (*K*) and flow behavior index (*n*) of pomegranate molasses at 20°C were determined by a Brookfield Programmable DV-II+ Viscometer equipped with a temperature probe and a guard leg (Brookfield Eng. Labs. Inc., Stoughton, MA, USA). Shear stress readings were obtained with a spindle (#4). In order to determine the flow behavior characteristics of pomegranate, the power-law model $\delta = K(\dot{\gamma})^n$, where δ is the shear stress (Pa), γ is the shear rate (s^{-1}), *K* is the consistency coefficient (Pa s^n) and *n* is the flow behavior index (dimensionless), was used [21].

Statistical analysis: One sample Z test (Minitab® Release 14 Statistical Software, Minitab Inc.) was used to determine whether flow behavior of molasses was equal to one.

Results and Discussion

Edible portion of pomegranates consists of mainly water (81%) and carbohydrates (17.2%) while it contains small amounts of protein (1%), fat (0.3%) and ash (0.6%) [2]. According to USDA National Nutrient Database [2], calcium, magnesium, phosphorus and potassium content of pomegranate arils are 3.0, 3.0, 8.0 and 259 mg/100 g, respectively. Pomegranate molasses evaluated in this study had 24.4% moisture, 0.2% protein and trace amount of ash on average (Table 1). Filtration and clarification of pomegranate juice during commercial processing may be the main reason for low protein and ash content of pomegranate molasses in comparison to fresh pomegranate. Evaporation of water during the production of molasses increases the concentration of carbohydrates in the final product.

The pH of pomegranate molasses was about 1.74, which comes predominantly from the organic acids of pomegranate fruit [1]. Hunter *L*, *a* and *b* color values of pomegranate molasses were 1.88, 0.57 and -0.31, respectively. Because pomegranate molasse is a concentrated product of pomegranate juice, *Lab* color values correspond to dark, slightly red and blue in color. Kaya and Sozer[22] reported a pH of 2.05 and *Lab* values of 5.54, 2.30 and 2.39 in pomegranate juice concentrates with 71°Brix. These values are slightly different from ours for pomegranate molasses. Small differences in pH and color values may arise from the differences in pomegranate fruit composition and processing steps of commercial pomegranate molasses, especially filtration and clarification.

Table 1. Physical and chemical properties of pomegranate molasses.

Property	Value
Moisture (%)	24.43±2.12
Brix	73.90±2.30
Protein (%)	0.23±0.06
Ash (%)	Trace
pH (at 17.5°C)	1.74±0.09
Specific weight	1.396±0.01
Total phenolic content (mg GAE/g)	52.56±20.68
Color values (Hunter *Lab*)	
L	1.88±0.52
a	0.57±0.08
b	-0.31±0.36

Kulkarni and Aradhya [7] reported that the total phenolic content of pomegranate arils, edible portion which includes seeds and fruit juice, depends on the fruit development and maturation. Authors reported the highest phenolic content of pomegranate arils (about 5 mg gallic acid equivalent (GAE)/g) at the 20 days of fruit set. Our results showed that total phenolic content of pomegranate molasses was about 52.6 mg GAE/g, meaning that total phenolic content of pomegranate molasses available in Turkish market is about 5 to 10 times higher than fresh pomegranate arils. Increase in total phenolic content of pomegranate molasses is mostly due to the evaporation of water during processing.

Total phenolic content of edible plants is usually determined in terms of gallic acid equivalent. Kale was reported to have the highest total phenolic content (16.3-18.8 mg GAE/g) among various vegetables including tomatoes, rhubarb, spinach and broccoli [23]. Total phenolic contents for kiwi fruit, Fuji apple, pear, carrot and orange were reported to be between 1.2 and 5.1 mg GAE/g dry weight [24]. Results of the present study showed that a few grams of pomegranate molasses with a total phenolic content of 52.6 mg GAE/g is able to make a significant contribution to the total daily intake of dietary phenolics in human diet.

Results of this study revealed that pomegranate molasses are rich in macroelements such as calcium, phosphorus and potassium as well as in trace minerals such as iron, copper, zinc and magnesium (Table 2). To the best of our knowledge, this is the first study reporting mineral composition of pomegranate molasses. Pomegranate molasses are concentrated products of pomegranate juice, which is a good source of various minerals [4]. Sodium and potassium concentrations in pomegranate molasses

Table 2. Comparison of mineral composition of pomegranate molasses with pomegranate juice.

Mineral	Mineral content (mg/kg)	
	Pomegranate molasses	Pomegranate juice[A]
Copper	0.61±0.01	0.3±0.1
Zinc	7.14±1.70	0.6±0.2
Iron	15.81±1.96	0.9±0.7
Manganese	0.23±0.10	0.2±0.1
Calcium	280.30±15.10	200.6±24.7
Potassium	20.12±0.20	1291.0±12.0
Magnesium	28.00±0.59	42.0±8.8
Sodium	148.15±4.60	229.0±24.7
Phosphorus	15.57±1.97	-

[A]from Fadavi *et al.*[4]

were 148 and 20 mg/kg, respectively, and these values were surprisingly lower in molasses than juice (Table 2). Calcium and magnesium concentrations in molasses were 280 and 20 mg/kg, respectively, and they were lower than expected concentrations. During the production of pomegranate molasses, approximately two third of water present in juice is removed through evaporation and concentrated juice is clarified and filtered. These processing steps may be a major reason for the loss in minerals. However, our study on the mineral composition of molasses revealed that the final product may still retain considerable amount of minerals present in juice.

Results of rheological measurements showed that pomegranate molasses exhibited a Newtonian flow behavior. One sample Z test resulted in that flow behavior index of molasses was equal to 1. Our results were similar to those reported by Kaya and Sozer [22] for pomegranate juice concentrate with a similar soluble solid content.

Conclusions

In conclusion, our study showed that pomegranate molasses are a good source of dietary minerals and phenolic constituents. Pomegranate molasses exhibit a Newtonian flow behavior. The effect of processing conditions, especially clarification and filtration, on mineral composition of pomegranate molasses and the biological availability of minerals in pomegranate molasses need to be further studied.

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